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(54) Injection molded battery containment for bipolar batteries.

(57) An injection molded containment for bipolar batteries of the type which include terminal electrodes and one or more bipolar battery cells is disclosed. In the most preferred embodiment of the present invention, a novel spacer is employed, including beveled edges to facilitate sealing of the injection molding material and the individual cells. Furthermore, the preferred spacer includes a crush ridge to assist in sealing. The present invention facilitates assembly of bipolar batteries in a way which improves sealing when compared to other techniques, such as vibration welding.

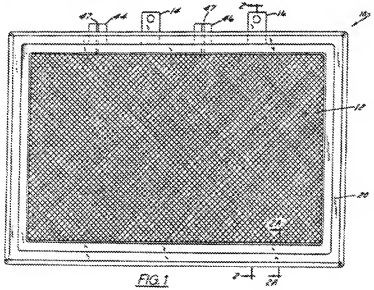

FIG.1

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to batteries and in the preferred embodiment to batteries of the bipolar type. Still more particularly, the present invention relates to containment systems for such batteries. In its most preferred embodiment, the present invention relates to a monolithic system for containing a plurality of battery components, including terminal electrodes and one or more battery cells. In its most preferred embodiment, the present invention relates to an injection molded monolithic containment system and a novel spacer.

Description of the Prior Art

A number of different systems have been proposed for containing battery components of both the monopolar and bipolar types, all as described in several of the patents which will be discussed in greater detail hereafter. Especially in the area of bipolar batteries, the tendency has been to create individual battery cells and to weld them together, such as by using friction or vibration welding. See, for example, U.S. Patent No. 4,948,681. Basic bipolar battery technology is described in U.S. Patent No. 4,900,643. A further patent describing bipolar batteries is U.S. Patent No. 5,004,655.

One problem encountered in the commercialization of the bipolar battery technology has been electrolyte leakage, either from individual cells or from combined cells. In addition, the containment systems used in prior bipolar technology have not provided satisfactory support of the internal components such as separators, electrodes, spacers and substrates, resulting in plate distortion and separator damage. A system which would overcome the problems of electrolyte leakage and proper support for the bipolar battery components would represent a significant advance in the art.

SUMMARY OF THE INVENTION

The present invention features a monolithic battery containment system which, rather than relying on combining individual cells, relies on injection molding to contain a plurality of battery elements.

The present invention further features a spacer configuration which includes both a crush ridge and beveled edges to improve sealing to adjacent spacers and sealing around the periphery thereof.

The present invention still further features a clamping and sealing technique which prevents damage to the internal components of a bipolar battery during assembly and containment.

The present invention also features a containment system in which the compression level applied to a battery component stack is selected for the amount of separator compression required for the battery to function properly.

The present invention further features an injection molding system in which the outer surfaces of the spacers and the bipolar electrode substrate (if the substrate is a thermoplastic) are fused to one another to result in better bonding and sealing.

Generally, an injection molding system provides a frame-like containment for a plurality of generally planar battery components. In a most preferred bipolar battery prepared according to the present invention, each spacer contains one set of positive and negative electrodes disposed on separate substrates and a separator therebetween. The spacers, with the associated battery components, are stacked in the desired number and terminal electrodes are applied thereto. The stack is then placed into an injection mold which clamps the stack to compress it to a thickness determined by the thickness of the spacers and other components. The compression is maintained by a plastic containment formed around and over the periphery of the stack. When the plastic is injected, it melts the outside edge of the spacers and the bipolar electrode substrates (if the substrates are thermoplastic). After molding is completed, separate steps are performed to produce filling/venting ports in the battery container such as by drilling, milling, insertion of a hot tool, etc. In the most preferred form of the invention, the adjacent components of the electrodes, terminal electrodes and spacers are treated with a compound which assists in preventing acid leakage. Furthermore, in the preferred embodiment, a unique spacer is employed which includes beveled edges to assist in the fusion mentioned above and which also include a crush ridge to assist in the bonding of one spacer to another or to a terminal electrode.

DESCRIPTION OF THE DRAWINGS

In the various drawings described below, like reference numerals are used to indicate like components.

FIGURE 1 is a front elevation view of a bipolar battery including the monolithic frame-like container of the present invention;

FIGURE 2 is a cross section taken along the line 2-2 of FIGURE 1 and showing the interior battery components for a five cell battery and also showing the terminal electrodes;

FIGURE 2A is an enlarged cross-section taken along the line 2A--2A of FIGURE 1,

FIGURE 3 is a front perspective view of the spacer used in the battery shown in FIGURES 1

and 2:

FIGURE 4 is an enlarged end view of the spacer shown in FIGURE 3; and

FIGURE 5 is an enlarged end view of a portion of the spacer and illustrating the crush ridge taken along the line 5--5 of FIGURE 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Before proceeding to the detailed description of the most preferred embodiment of the present invention, several comments should be made about the applicability and scope of this invention. First, the materials specified later in this specification are exemplary, and other materials having properties suitable for use in the harsh environment of lead-acid batteries could be readily substituted therefor. Second, the size and shape of the components can vary widely, depending on the power requirements for the battery and space requirements. In this regard, the number and cross sectional area of the various cells and cell components can vary, for example, from 2" by 4" to more than 18" on a side or larger.

Third, the particular spacer shown in the present invention is preferred, but standard spacers which are generally rectangular in perimeter cross section may be used. Also, the crush ridge (to be described later) could be eliminated without departing from the intended scope of the invention. As will be explained more fully, the ridge assists in sealing of the plastic surfaces to one another, while the bevel around the spacer periphery assists in the fusion process to provide a tight seal to prevent movement of internal components and leakage of electrolyte.

Fourth, a sealing aid is described later in the specification, again for use in the most preferred embodiment of the invention. Other materials can be used to assist in the sealing of one component to another, and those skilled in the art would readily appreciate which sealing agents could be substituted for the disclosed types.

Finally, it should be indicated that the particular type of molding equipment used for injection molding the containment frame around the battery elements is a matter of design choice and one skilled in the art could readily select appropriate equipment. What is important is that the assembled elements to be described later are compressed to the degree necessary for proper battery performance and held in this compressed condition while the molding operation takes place.

Proceeding now to FIGURE 1, a battery 10 according to the most preferred embodiment of the present invention includes a first terminal electrode 12 (which, in this example, will be the negative terminal electrode), a pair of spacer tabs 14 and 16 extending from the top of the battery, and a frame-like containment 20 surrounding the entire battery but leaving the face of the terminal electrode 12 (and the face of the positive terminal electrode (not shown), exposed. An area 18 located interiorly of the containment 20 is shown on FIGURE 1 and is a mold clamp area, i.e. the area in which the clamps (not shown) are applied during compression of the battery components while injection of the molding material used to form containment 20 takes place.

The internal components of battery 10 can better be appreciated by examination of FIGURE 2, which shows a five cell battery formed of five spacers 22, the negative terminal electrode 12 and a positive terminal electrode 24. The spacers 22 are each sized to abut a bipolar battery substrate 26 and surround a positive electrode 28 applied to one side thereof and a negative electrode 30 applied to the other side thereof. The spacers are also sized to contain a separator sheet 32 located between electrodes 28 and 30, the latter being under compression during molding.

The individual components used in the formation of the bipolar battery are not described in greater detail here because, in and of themselves, they are well known and do not form part of the present invention. Also not illustrated in this FIGURE 2 are the fill holes which are provided in additional spacer tabs described in FIGURE 3, it being appreciated that fill holes and vents are necessary in batteries of this type. It will also be apparent to those skilled in the battery art that by employing five spacers, each containing and abutting the elements described above, a five cell battery will result when the positive and negative terminal electrodes (12 and 24) are included. If each electrode cell is designed for 2V output, the five cell battery 10 will be a 10V system.

In connection with FIGURE 3, one of the spacers 22 is shown in greater detail to include a generally rectangular frame 40 having a generally rectangular opening 42 therein to receive the electrodes and separators previously identified. Two additional tabs are shown at 44 and 46, each including an elongate channel 47 extending from the tip of the tab to the interior opening 42. These channels, when combined with other spacers, will form channels useful for venting and filling, as previously discussed. Another feature of the spacer 22 which is best shown in FIGURE 4 is a beveled edge 50. Edge 50 assists in the overall sealing of the battery to be described later. The particular angle of the bend is not critical, however.

The final feature of spacer 22 is a crush ridge 52, shown best in FIGURE 5. A recess 53 is provided on the opposite side of the spacer. The crush ridge 52 has been found to increase the

sealing efficiency as spacers are compressed against an adjacent component, i.e. a substrate, prior to the application of molding material. The height of ridge 52 is preferably equal to the difference between the substrate thickness and the depth of the recess 53. For example, for a spacer which is 0.080 inches and where the substrate is 0.020 inches, recess 53 is preferably 0.028 inches deep to cause the ridge 33 to be 0.006 inches in height. The ridge 52 will therefor push the substrate into recess 53 as compression takes place.

With regard to materials, the spacer 26 of one of our most preferred embodiment is made from glass filled high density polyethylene, but other thermoplastic materials useful in bipolar battery components of the prior art could be substituted therefor. These include such materials as low density polyethylene, polypropylene and the like. A particularly suitable material is a thermoplastic rubber, Santoprene®, sold by Monsanto Chemical. Use of this material may eliminate the need for either sealing aids or the crush ridge, since the rubber properties allow desirable bonding to adjacent components, acting like a gasket.

With respect to the sealing aid mentioned previously, we have found that the application of an acid resistant rosin or rubber compound, such as chlorosulfanated polyethylene (CSM) also assists in improving sealing. Two suitable CSM materials are Hypalon® manufactured by Minor Rubber Company, and the CSM distributed by E.I. du Pont. The sealing aid is typically dissolved in a solvent, such as 1, 1, 1-trichloroethane.

Now that the major components of the battery of the present invention have been described, the containment itself can be further discussed. The materials used for the injection molded containment 20 are preferably thermoplastic resins such as high density polyethylene, ABS, polypropylene and polyethylene (low density or high density). Generally, any resin which is thermoplastic and which can withstand the acid environment of lead-acid batteries can be employed. Resistance to temperatures between about -50°F and 170°F is also highly desirable.

The heated molding material is injected around the periphery of the spacers and terminal electrodes to contain all of the components described above. The injection molded material is liquid and will flow around the battery exterior to form containment 20. It is most desirable that the temperature be suitable to fuse at least some of the containment material to the beveled edges 50 of the spacers 22 and also the substrates 28, if they include thermoplastic components. Such fusion results in better leak prevention and in assuring that the internal electrode components are properly supported and will not move during use. During the molding process, the area between spacers 22 in the vicinity of beveled edges 50 will receive molten thermoplastic molding material, causing the fusion to occur and ensuring efficient bonding.

While the present invention has been described in connection with certain preferred embodiments, it is not to be limited thereby but is to be limited solely by the scope of the claims which follow. For example, while a wood rosin could be used instead of the CSM materials as a sealing aid, various urethanes and silicones could also be used. Furthermore, holes could be provided in the substrates and spacers to align the various components prior to the compression operations. The terminal electrodes themselves would normally include taps or studs for connecting the battery to a desired output, and the materials used for the terminal electrodes could be either alloys or highly conductive carbon/resin composites used in newer bipolar systems. Accordingly, what we claim is as follows:

Claims

1. A battery having generally planar terminal electrodes and at least one bipolar battery cell located intermediate the terminal electrodes, the battery having a peripheral edge and further including a frame-like, monolithic injection molded thermoplastic resin container adhering to and surrounding the peripheral edge but leaving portions of the terminal electrodes exposed.

2. The battery of Claim 1, wherein each bipolar battery cell includes a thermoplastic resin spacer surrounding positive and negative electrodes and a separator located between the electrodes.

3. The battery of Claim 2, wherein each spacer includes a beveled edge on at least a portion of its peripheral edge.

4. The battery of Claim 2, wherein each spacer includes an outer penpheral edge, an inner edge defining an opening to receive the electrodes and separator, and a crush ridge intermediate the peripheral edge and the inner edge.

5. The battery of Claim 2, wherein the container is at least partially fused with the peripheral edge of each spacer.

6. The battery of Claim 2, wherein a sealing aid is located between adjoining surfaces of thermoplastic battery components.

7. The battery of Claim 6, wherein the sealing aid is a chlorosulfonated polyethylene.

8. The battery of Claim 1, wherein the terminal electrodes and intermediate cells are under compression.

9. A method of making a bipolar battery of the type which includes generally parallel and spaced apart terminal electrodes and bipolar battery cells disposed therebetween, comprising the steps of:

stacking the terminal electrodes and cells;

applying a compressive force to the terminal electrodes; and

injection molding a frame-like thermoplastic resin container around the periphery of the compressed stack leaving exposed a portion of the terminal electrodes.

10. The method of Claim 9, wherein each bipolar battery cell includes a thermoplastic resin spacer adjacent to a conductive substrate and surrounding positive and negative active electrodes and a separator and wherein the molding step including joining the container to each spacer.

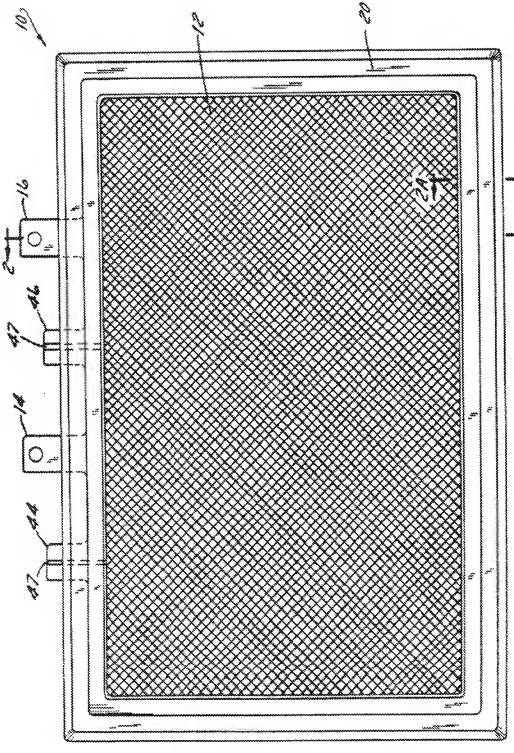

FIG. 1

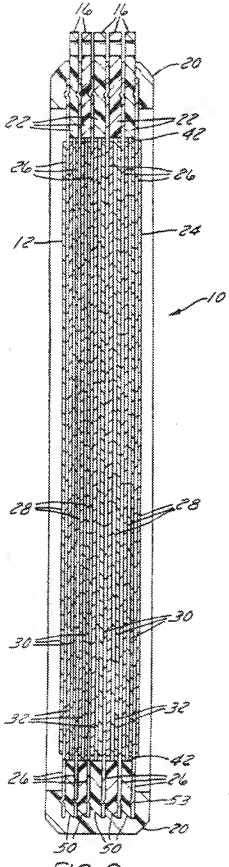
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FIG. 2

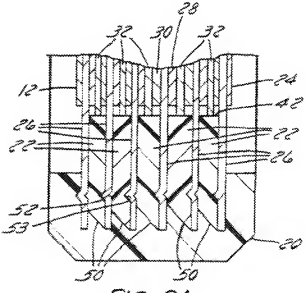
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FIG. 2A

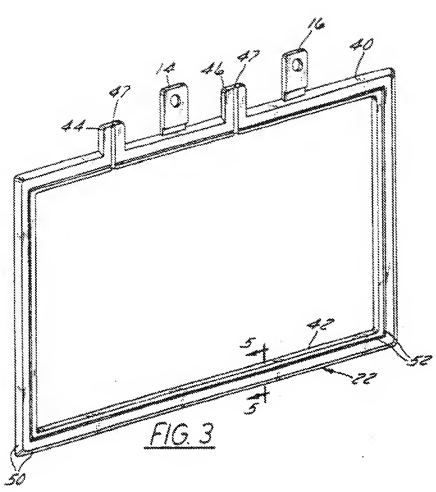

FIG. 3

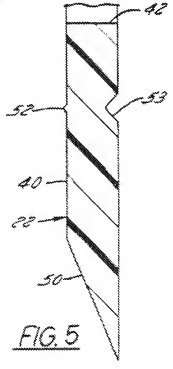

FIG. 5

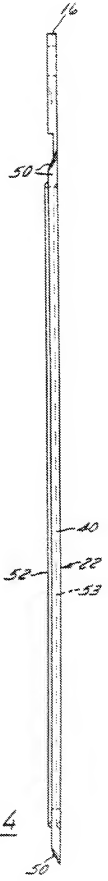

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 95 25 0052

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of documents with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	PATENT ABSTRACTS OF JAPAN vol. 13 no. 468 (E-834) ,23 October 1989 & JP-A-01 183071 (MEIDENSHA CORP) * abstract *	1,2,4,6, 8-10 7	H01M10/04 H01M2/02
Y	PATENT ABSTRACTS OF JAPAN vol. 6 no. 147 (E-123) ,6 August 1982 & JP-A-57 072261 (MATSUSHITA ELECTRIC IND CO) * abstract *	7	
X Y	FR-A-1 024 163 (DIMITRI ISSAIEWITCH REBIKOFF) * page 1, column 2, line 4 - page 3, column 2, line 2 *	1,8,9 2	
Y	GB-A-2 160 704 (LABORATORIET FOR ENERGIFORSKNING) * page 5, line 4-121 *	2	
X	EP-A-0 402 265 (COMPAGNIE EUROPEENNE D'ACCUMULATEURS) * claims 1-16 *	1,2	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01M
X	WO-A-87 04011 (NESTE OY) * page 3, line 19 - page 4, line 22; claims 1-11 *	1,8,9	
P,X	EP-A-0 631 338 (GENERAL MOTORS CORPORATION) * column 6, line 39 - column 7, line 46; claims 1-10 *	1,2,8-10	
A	FR-A-2 304 188 (OLLE LINDSTROM) * page 14, paragraph 2-30 *	1-10	
A	WO-A-92 22936 (SORAPEC) * page 14, line 30 - page 16, line 3 *	1,8,9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 July 1995	De Vos, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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